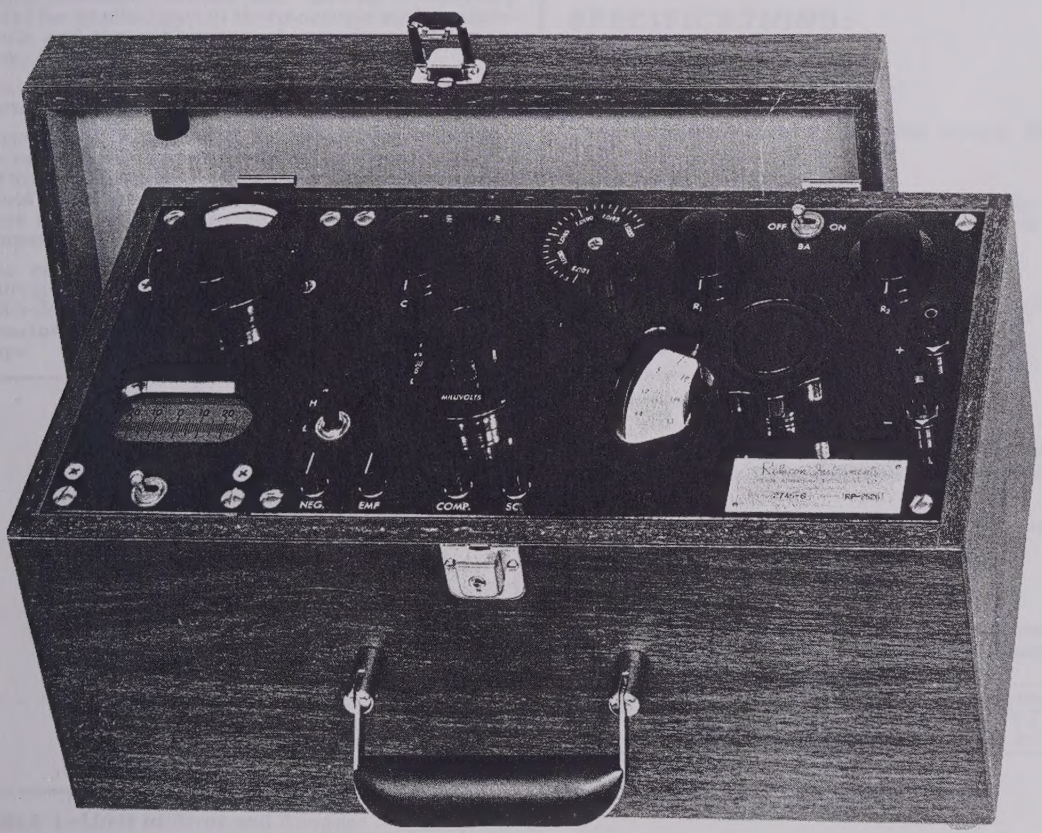
Technical Manual

INSTRUCTIONS FOR

PORTABLE PRECISION POTENTIOMETER

MODEL 2745G/N



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MODEL 2745

PORTABLE MILLIVOLT POTENTIOMETER

GUARANTEED LIMIT OF ERROR:
±0.03% of first dial reading + 0.3% of slidewire span + 0.3% of compensator range when used.

RANGES:
High: 0 to 80.5 millivolts
Low: 0 to 16.1 millivolts

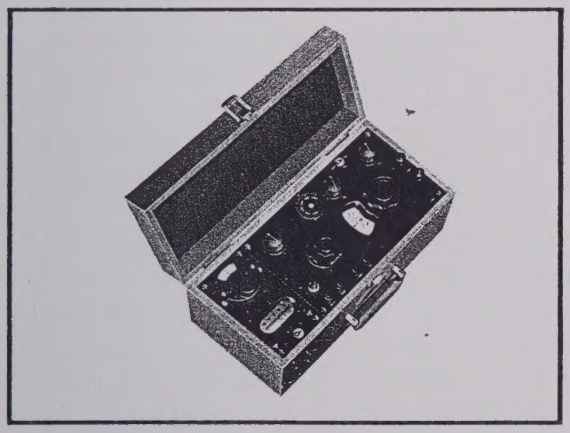
DESCRIPTION:

The Model 2745 Portable Millivolt Potentiometer is a self-contained precision instrument providing a unique method of manual compensation for thermocouple reference junction emf, making it especially useful for applications in thermocouple emf measurements and the calibration of recording potentiometers.

Two measuring ranges cover the entire span of thermocouple emf's.

A reversing key is used for measurements below the reference temperature upon which the tables in use are based. Thus, a continuous series of measurements above and below the table reference temperature may be made, requiring no readjustment of compensator or reversal of thermocouple leads.

Two compensator ranges are provided, 0 to 1.1 millivolts, adjustable to ±0.001 millivolt; and 0 to 5.5 millivolts, adjustable to ±0.005 millivolt. Either compensator range may be used with either measuring range.



SPECIFICATIONS:

Limit of Error:
Refer to Table I.

Ranges:
Dual measuring and compensator ranges. Refer to Table I.

Batteries (Self-Contained):
Three 1.5 volt No. 6 dry cells—one each for potentiometer current, compensator current, and galvanometer lamp.

Galvanometer (Self-Contained):
POINTERLITE type, 50 mm. zero-center scale with 1 mm. divisions.
Sensitivity—.3 microampere per millimeter.
Resistance—10 ohms, CDRX—30 ohms.
Period—2 seconds.

Case:
Sturdy melamine case with carrying handle, lock, rubber bumpers, and removable hinged cover.

Dimensions:
15¼ inches long, 8⅝ inches wide, and 8 inches high.

Weight:
23 pounds, including batteries.

Thermometer:
Seven-inch, clip mounted in potentiometer case when specified on order. Specify Part No. and Range.

Part No.	Range	Divisions
726721-1	30 to 120°F	1°F
726721-2	0 to 220°F	2°F

Specification Reference: D-2082.

TABLE I—Limit of Error and Ranges:

Measuring Range (millivolts)			Compensator Range (millivolts)	*Limit of Error
Range	Stepswitch	Slidewire		
0-16.1 (low)	0-15	0-1.1	0-1.1 (low)	0.01 millivolt
0-16.1 (low)	0-15	0-1.1	0-5.5 (high)	0.02 millivolt
0-80.5 (high)	0-75	0-5.5	0-1.1 (low)	0.04 millivolt
0-80.5 (high)	0-75	0-5.5	0-5.5 (high)	0.05 millivolt

*Listed values calculated using maximum dial settings and maximum compensator range shown.
For other than maximum dial settings: ±0.03% of first dial reading plus 0.3% of slidewire span, plus (when in use) 0.3% of compensator range.

INSTRUCTIONS FOR

PORTABLE PRECISION POTENTIOMETER
MODEL 2745

April 1972

755624

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INSTRUCTIONS FOR

PORTABLE PRECISION POTENTIOMETER

MODEL 2745

1. DESCRIPTION

This potentiometer was designed especially for thermocouple emf measurements, and incorporates means of manual compensation for the emf of the thermocouple reference junction.

The two measuring ranges (0 to 16.1 millivolts and 0 to 80.5 millivolts) can be used with either of the two reference junction compensator ranges of 0 to 1.1 millivolts and 0 to 5.5 millivolts.

The measuring ranges are covered by a sixteen point step switch and a slidewire, dials (3 and 4, Fig. 1) and (A and B, Fig. 2), respectively. The reference junction emf is developed across resistors "E" and is adjusted by rheostat C against a setting of the slidewire (4, Fig. 1). Having adjusted the reference junction emf to a given value, it then remains unchanged during subsequent operations of the step switch (3, Fig. 1) and slidewire "B".

An added feature of this instrument extends the technique of manual reference junction compensation to the entire range of sub-zero thermocouple measurement. A reversing key, designated "NEG", is used for measurements below the reference temperature on which the tables in use are based. Thus, a continuous series of measurements, above and below the reference temperature, can be made without readjustment of the compensator or reversal of thermocouple connections.

Two rheostats, "R_1" and "R_2", for adjustment of the current in the measuring potentiometer are provided.

This instrument is entirely self contained, including a combination pointer and refleeting (Pointerlite) galvanometer,* standard cell, three No. 6 dry cells, together with the necessary keys, switches, and binding posts. One dry cell is used for the current supply of the measuring potentiometer, one for the auxiliary emf of the reference junction compensator and one for the galvanometer lamp. The "LAMP" toggle switch which operates the galvanometer lamp, short circuits the galvanometer in the OFF position, adapting the instrument for use as a source of emf for checking other potentiometer instruments as directed in paragraph 8.

2. ADJUSTMENT OF THE GALVANOMETER ZERO

Adjust the pointer of the galvanometer to the zero line on the scale, if necessary, by rotating the knurled adjustment knob (1, Fig. 1). Set the LAMP key to the ON position (to the right) to light the galvanometer lamp. If the line on the indicating spot

*For instruments with an Electronic Null Detector, refer to Appendix A, Page 11.

of light does not coincide with the zero on the glass scale, adjust by pressing down on the scale, exerting sufficient force at the same time in the desired lateral direction.

3. ADJUSTMENT OF POTENTIOMETER CURRENT

Set the battery switch BA to the ON position. Set the LAMP switch to the right to light the galvanometer lamp. Tap the S.C. key and adjust the coarse battery rheostat R_1, observing the galvanometer pointer until an initial balance is obtained. Press the S.C. key and adjust the fine battery rheostat R_2 until final balance is indicated by the galvanometer light beam index. When adjusting the potentiometer current, the range switch (2, Fig. 1) may be in either the high or low position (H or L).

4. CONNECTIONS

a. Connect the thermocouple to the EMF binding posts, observing the correct polarity. The polarity of connections of some common types of thermocouples is indicated in the table.

THERMOCOUPLE POLARITY

Positive (+)	Negative (-)
Iron	Constantan
Copper	Constantan
Chromel	Alumel
Platinum-Rhodium	Platinum

b. When measuring temperatures below the reference temperature on which the temperature versus millivolt tables used are based, connect the thermocouple leads to the EMF binding posts with the same polarity, based on the table above.

5. ADJUSTMENT OF REFERENCE JUNCTION COMPENSATOR

a. Measure the temperature of the thermocouple reference junction with a good mercury thermometer to an accuracy of at least .25 degree Fahrenheit. Refer to the appropriate temperature versus millivolt tables to obtain the emf corresponding to the temperature of the reference junction. The actual reference junction is that point which the thermocouple wires or compensating lead wires connect to the copper wires in the circuit, usually at the EMF binding posts.

b. If the emf corresponding to the reference junction temperature is less than 1 millivolt, set range switch (2, Fig. 1) to the L position. If more than 1 millivolt, set the range switch to the H position.

c. Adjust the potentiometer current as instructed in paragraph 3.

d. Set the emf value corresponding to the reference junction temperature, as determined from paragraph 5a, on the slidewire (4, Fig. 1), being sure to use the scale indicated by the position of the range switch; i.e., if the range switch is in the L position, use the low or inner scale. If the range switch is in the H position, use the high or outer scale.

e. Tap the COMP key and adjust knob C until an approximate balance is obtained, observing the galvanometer pointer. Press the COMP key and complete the balance by adjusting the knob C until final balance is indicated by the galvanometer light beam index.

6. MEASUREMENT

a. If it is known or can be estimated that the measured emf is more than 16 millivolts, or if the value of the emf is entirely unknown, set the range switch to the H position.

b. It is assumed that the potentiometer current has been checked and adjusted according to paragraph 3 and the reference junction compensator has been adjusted as instructed in paragraph 5. Set the step switch (3, Fig. 1) and slidewire (4, Fig. 1) to zero. Tap the EMF key, and at the same time rotate the step switch until the galvanometer deflection changes direction. Turn the step switch back to the last previous step and complete the balance with the slidewire. If the balance obtained on the high range indicates that the measured emf is less than 16 millivolts, set the range switch to the low range or L position and repeat the balance for maximum precision. Obviously the proper scale on the step switch and slidewire must be used, corresponding to the position of the range switch.

c. It is good practice before taking a final reading, to recheck the potentiometer current and adjust if necessary, according to paragraph 3. Recheck the mercury thermomenter reading of the reference junction temperature and readjust the compensator according to paragraph 5. If any readjustment in either case is necessary, a slight change in the balance according to paragraph 6b will result.

d. The temperature of the measuring junction of the thermocouple is then obtained by adding the readings of the step switch and slidewire and referring to the appropriate temperature versus millivolt tables for the corresponding temperature.

For example, assume that measurements are being made with a copper-constantan thermocouple, whose reference junction temperature is found to be 70°F as measured with a reliable mercury thermometer. Referring to the temperature vs. millivolt tables for copper-constantan thermocouples with a basic reference junction temperature of 32°F, the corresponding emf is found to be .832 millivolt. Set the range switch to the L position and the slidewire to the emf value, and adjust knob C as directed in paragraph 5. Obtain a balance as

instructed in paragraph 6a. The temperature of the thermocouple measuring junction can then be found in the temperature vs. millivolt tables, corresponding to the sum of the readings of the step switch dial and slidewire scale. The emf of the thermocouple reference junction has been added electrically to the measured emf by use of the reference junction compensator and no computation is necessary.

e. If it is known that the value of the emf to be measured is less than 16 millivolts, set the range switch to the L position and proceed otherwise as instructed in paragraph 6a and 6b.

f. The EMF key and NEG key (whose function is described in paragraph 7) are arranged to lock down so that slowly changing temperatures can be followed conveniently. All keys are interconnected so that the S. C. key may be pressed to standardize the potentiometer current with either one or both NEG and EMF keys closed without interference. The COMP key can be closed to check the compensator adjustment when the EMF key is locked down, but the NEG key must be released when this function is performed.

7. MEASUREMENTS BELOW THE TABLE REFERENCE TEMPERATURE

a. If it is impossible to balance the potentiometer as described in paragraph 6; that is, the potentiometer appears to approach balance below zero millivolts, the temperature of the measuring junction is below the reference junction temperature on which the tables used are based. In this case, as well as when it is definitely known beforehand that the measuring junction temperature is below the basic reference junction temperature, proceed as follows:

(1) The thermocouple must be connected to the EMF binding posts with the same polarity as indicated in paragraph 4. Do not reverse polarity of connections, even though the measured emf reverses.

(2) Measure the temperature of the thermocouple reference junction and adjust the reference junction compensator as instructed in paragraph 5.

(3) Depress and lock down the NEG key and proceed to balance the potentiometer as instructed in paragraph 6. In this case, the sum of the readings of the step switch and slidewire must be preceded by a minus sign (-) before referring to the appropriate temperature vs. millivolt tables. As in the measurement of temperatures above the table reference temperature, the temperature of the thermocouple measuring junction can be obtained directly from the tables. In this case the emf of the thermocouple reference junction has been subtracted electrically from the measured emf and no computation is necessary.

8. TO CHECK POTENTIOMETER RECORDERS, CONTROLLERS, AND INDICATORS

To check instruments of the above types having automatic reference junction compensation, follow the procedure outlined below:

a. Adjust the potentiometer galvanometer zero as directed in paragraph 2.

b. Adjust the potentiometer current as instructed in paragraph 3.

c. Adjust the potentiometer current in the instrument to be checked according to its instructions.

d. Measure the temperature of the reference junction compensator of the instrument to be checked with a mercury thermometer.

e. Set the emf corresponding to the temperature in d, above, on the slidewire (4, Fig. 1) of the potentiometer, adjusting the compensator emf with knob C as instructed in paragraph 5.

f. Connect the potentiometer EMF binding posts to the T.C. binding posts of the instrument to be checked, using insulated copper wire of any size between No. 14 and No. 18 and observing the correct polarity.

g. Short circuit the potentiometer galvanometer by setting the LAMP switch in the OFF position (to the left).

h. Start the recorder or controller, if the instrument to be checked is of that type.

i. Set the potentiometer range switch (2, Fig. 1), step switch (3, Fig. 1), and slidewire (4, Fig. 11) to the emf corresponding to the temperature at which the scale of the test instrument is to be checked.

j. Tap the EMF key and lock down by pressing and rotating clockwise as the instrument under test approaches balance.

The pen, print wheel, or other index of the test instrument should balance at the temperature corresponding to the emf at which the potentiometer has been set to within the combined accuracy of adjustment of the two instruments.

k. In checking instruments having manually operated reference junction compensators, the emf corresponding to the reference junction temperature must be set on the compensator dial of the instrument to be checked as well as on the potentiometer as described in d and e, above.

l. When the instrument under test has a range extending below the table reference temperature, depress and lock down both the EMF key and the NEG key. Except that the reading of the potentiometer is negative in sign (-), the procedure is as described above.

9. MAINTENANCE

a. Replacing Batteries

The three No. 6 dry cells are all accessible by removing three screws on the rear panel of the case and opening the hinged door.

The necessity of replacing the cell supplying the measuring potentiometer circuit is indicated when it is no longer possible to obtain a balance when adjusting the potentiometer current according to paragraph 3, or when the rate of change of this current is so rapid that frequent readjustment is required. The cell supplying the measuring potentiometer current is connected with a red lead to the positive (+) terminal and a black lead to the negative (-) terminal. This same polarity must be observed when installing a new cell.

The replacement of the cell supplying the reference junction compensator is indicated when it is impossible to obtain the maximum range of 5.5 millivolts as described in paragraph 5 or when frequent readjustment is required. The cell supplying the reference junction compensator is connected with an orange lead to the positive (+) terminal and a blue lead to the negative (-) terminal. This same polarity must be observed when installing a new cell.

The cell supplying the galvanometer lamp requires replacement when the indicating spot of light becomes too dim for satisfactory operation. The polarity of this cell is of no importance, but is connected with the green and white leads.

b. Replacing Galvanometer Lamp

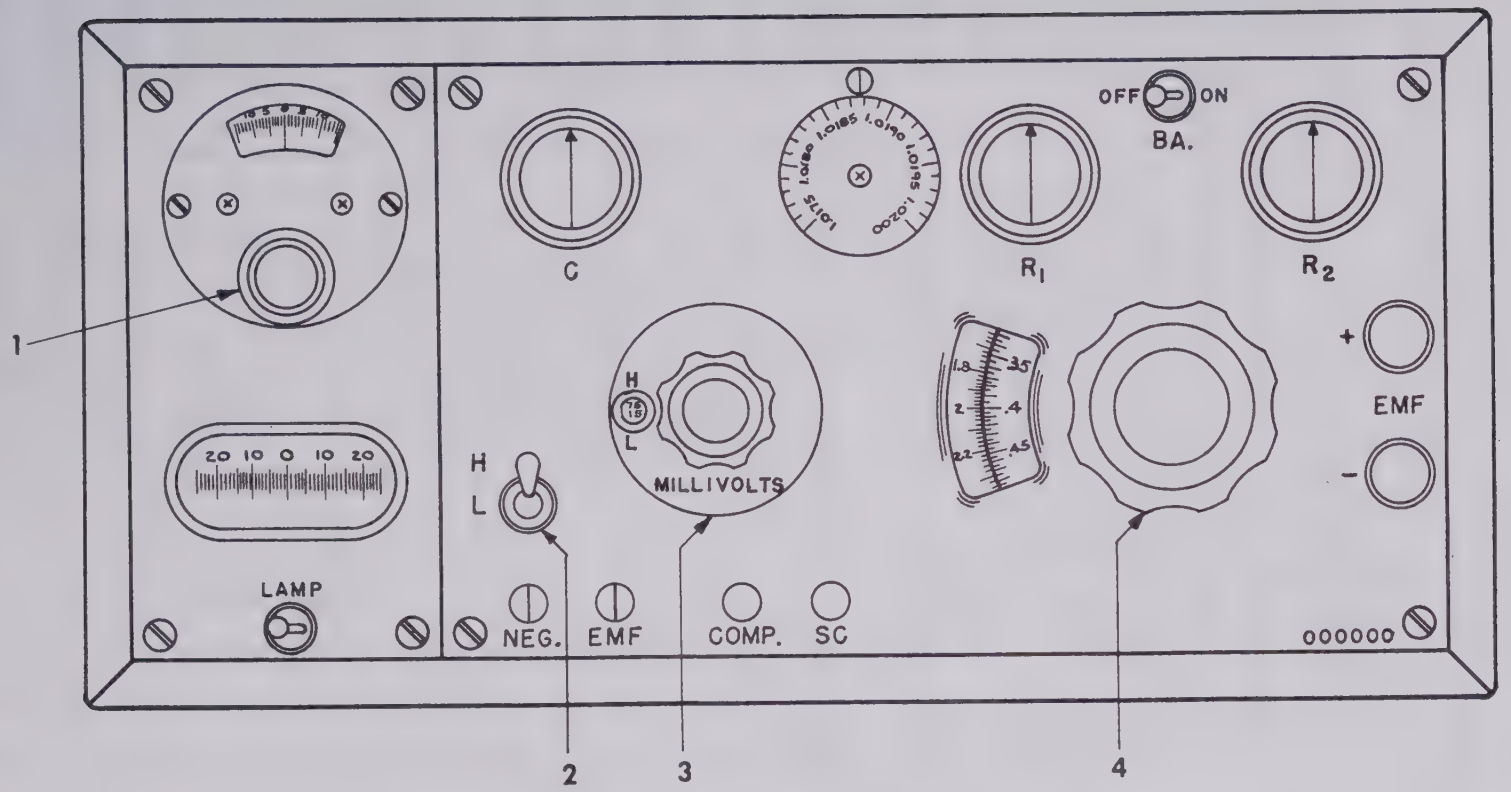
The galvanometer lamp also is accessible through the hinged door in the rear of the instrument. A spare lamp is furnished in a fuse clip mounted on the galvanometer frame.

The lamp is a Mazda #222 flashlight bulb, easily obtainable. It is suggested that several lamps be purchased in order to select one that gives a satisfactory image. If desired, selected lamps (Part 726397-1) can be obtained from Rubicon Instruments.

Remove the lamp socket from the end of the lens tube and replace the old lamp with a new one. Replace the lamp socket, set the LAMP switch to the right and rotate the socket until the best image is obtained. Unless selected bulbs are used, it may be necessary to try several lamps to obtain a good image. When the work is finished, set the LAMP switch to the left and move BA switch to the OFF position to conserve the battery.

c. Replacing Galvanometer System

The galvanometer system may be replaced, if required, as described on the enclosed Instruction Sheet 756662.



1. Adjustment Knob, Galvanometer
2. Range Switch
3. Step Switch
4. Slidewire

Fig. 1 - Top Panel View of Model 2745 G

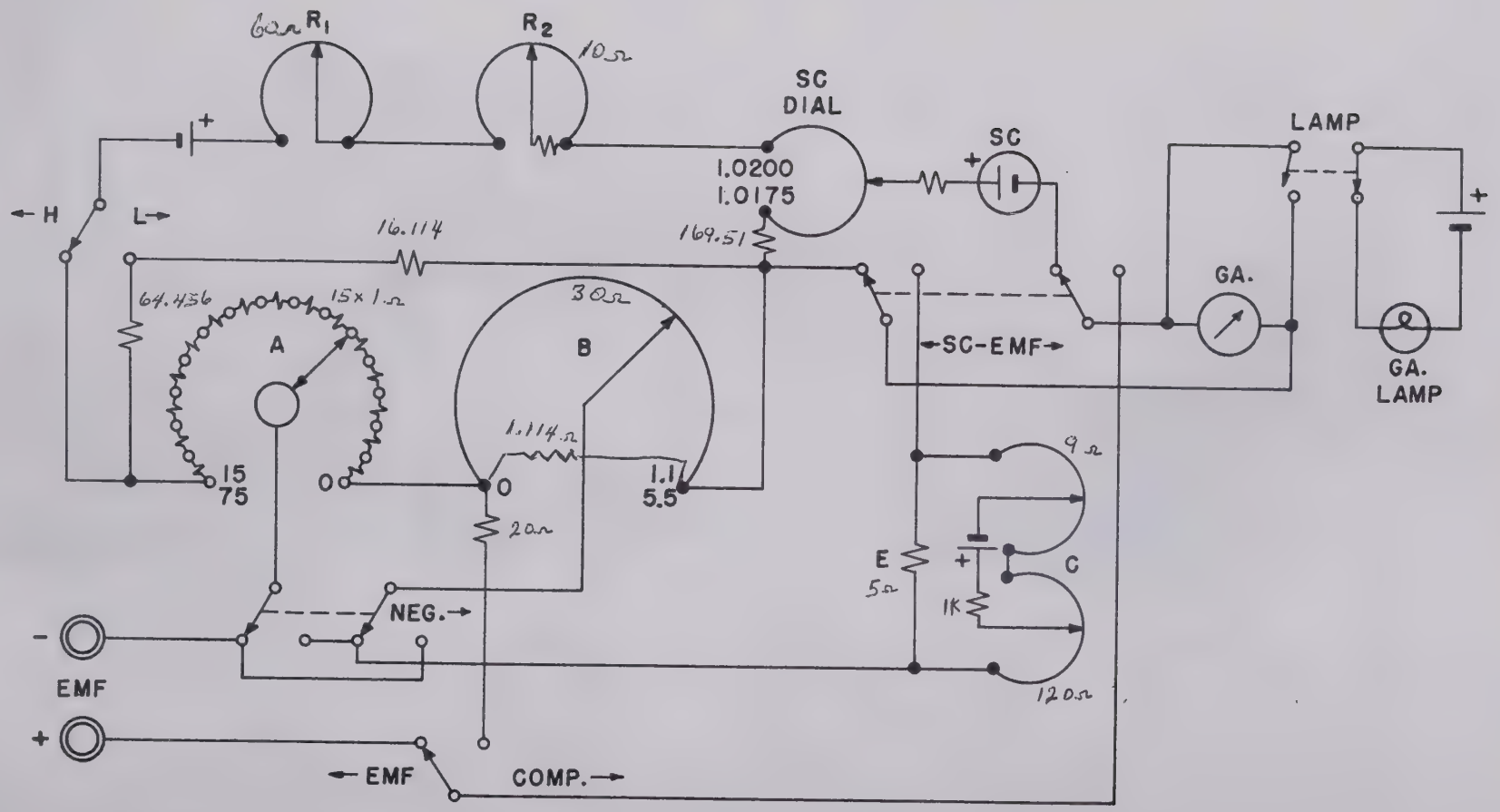


Fig. 2 - Schematic Diagram for Model 2745

REPLACEMENT PARTS FOR PORTABLE PRECISION POTENTIOMETER MODEL 2745

It is recommended that the instrument be returned to the factory for replacement of parts not listed in the following table.

When ordering Replacement Parts, specify the Model and Serial Number of the instrument requiring parts, and the part number and description of the parts required.

Part Number	Description
726210-1	Dry Cell, Eveready Columbia "Gray Label" Tel Battery No. 6
726204-1	Standard Cell, Eppley Cat. No. PYR
726667-2	Galvanometer System
726397-1	Galvanometer Lamp, Selected Mazda No. 222
726383-1	Glass Scale, Galvanometer
726432-1	Cap, Binding Post
726192-10	Knob, C, R_1, R_2
726192-3	Knob, Stepswitch
726192-9	Knob, Slidewire
726784-1	Switch, BA
726778-1	Switch, H-L
726869-1	Switch, Galvanometer Lamp
726158-5	Key, EMF and NEG.
726158-4	Key, SC and COMP.
726218-001	Double Rheostate, C
736079-006	Rheostate, R_1
736079-002	Rheostate, R_2
726269-004	Case Assembly

INSTRUCTIONS FOR
GALVANOMETER SYSTEM REPLACEMENT
SERIES 3000

The Series 3000 galvanometer system is of sturdy construction, but a severe shock may break the suspension. Failure of the galvanometer to deflect is indication of this condition, and replacement of the system is necessary. Replace it as follows:

1. Refer to Figure 1, and remove the two screws marked 1.

2. Lift the entire system clear of the top panel.

   NOTE: On some systems it will be necessary to disconnect the two wires from the terminal screws in the base.

3. Remove and discard either the shorting spring between the metal case and the contact spring under the flange of the molded top, or the shorting wire connected across the two terminal screws in the base before proceeding with steps 4 and 5.

4. Position the galvanometer system so that the scale reads correctly when viewed from the front of the instrument.

5. Insert the galvanometer system into the top panel and insert and tighten the two mounting screws (1, Fig. 1).

   NOTE: WIRE CONNECTED SYSTEMS ONLY: If the deflection is opposite to that to which you are accustomed, reverse the two wires at the system terminals.

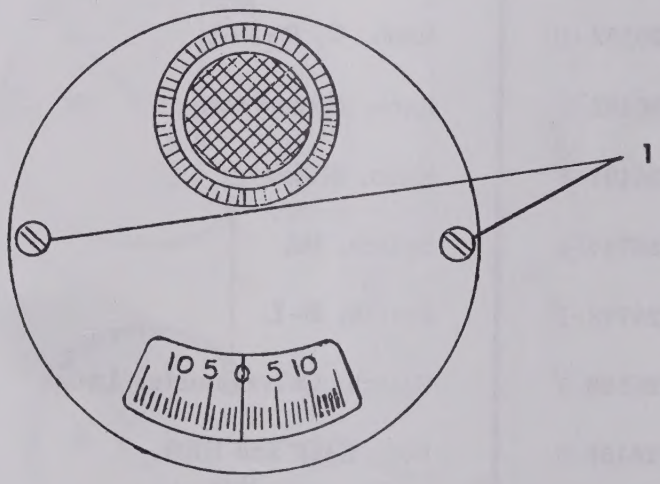


Fig. 1 - Top View of Galvanometer System

APPENDIX A

Instruments With Electronic Null Detector

The instrument is a complete potentiometer system including an Electronic Null Detector with its batteries, a standard cell, two No. 6 dry cells, together with the necessary keys, switches and binding posts. One dry cell is used for the current supply of the measuring potentiometer and one for the auxilliary emf of the reference junction compensation. The FUNCTION switch of the null detector when in the OFF position, adapts the instrument for use as a source of emf for checking other potentiometer instruments as directed in paragraph 8, page 5.

PRE-OPERATIONAL PROCEDURE

To prepare the null detector for operation, proceed as follws:

1. Check the meter pointer for accurate centering. Adjust with screw on front of meter, if necessary.

2. Set the FUNCTION switch to B and B to check batteries, then to desired range.

3. To check zero of the null detector be sure that both the SC key and EMF key are in their normal (up) positions. Adjust with ZERO knob if necessary.

ADJUSTMENT OF POTENTIOMETER CURRENT

Set the battery switch BA to the ON Position. Set the Funtion switch to 2500. Tap the S.C. key and adjust the course battery rheostate R_1 observing the meter pointer until an initial balance is obtained. Set the FUNCTION switch to 250, press the S. C. key and adjust the fine battery rheostate R_2 until final balance is indicated by the pointer. When adjusting the potentiometer current, the range switch (2, fig. 1) may be in either the high of low position (H or L).

Now proceed with paragraph 4, page 2—CONNECTIONS.

Note: For complete operating instructions and parts list for the null detector, refer to the Technical Manual for Model 3970 Guarded NULL DETECTOR, manual no. 765150-001.

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